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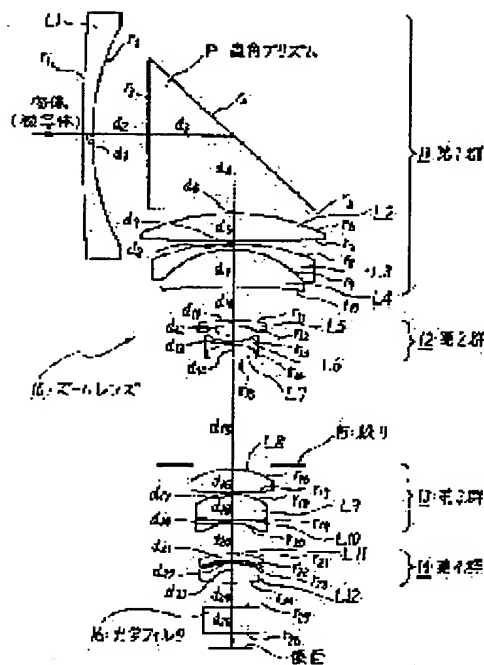
(54) ZOOM LENS

(57)Abstract:

PURPOSE: To obtain a zoom lens capable of enhancing the degree of freedom in design without making a video camera thick or slender and making the diameter of a front lens smaller though the angle of view at a wide-angle end is wide.

CONSTITUTION: This zoom lens 10 is constituted by arranging a 1st group 11 having positive refractive power, a 2nd group 12 having negative refractive power, a diaphragm 15, a 3rd group 13 having the positive refractive power, and a 4th group 14 having the positive refractive power in order from an object side. The 1st and the 2nd groups 11 and 12 constitute a variable power system. The 1st group 11 is constituted by arranging a concave lens L1, a rectangular prism P, a convex lens L2, and a bonded lens of a concave lens L3 and a convex lens L4 in order from the object side.

Since the optical axis of a light beam from the object is bent at a right angle by the prism P, the length in an incident optical axis direction is drastically shortened. By allowing the prism P to intervene, a distance between the concave lens L1 and the group of the lenses L2 to L4 becomes long and the rear side principal point of the 1st group 11 are brought near to the rear, so that the focal distance of the 1st group 11 is shortened, which is advantageous to attain the wide angle.



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 CLAIMS

[Claim(s)]

[Claim 1] The variable power system which becomes order from the 1st group which has positive refractive power, and the 2nd group which has negative refractive power from a body side, In the zoom lens with which drawing and the 4th group in which movement for having positive refractive power, always having the 3rd group of fixation and positive refractive power, and adjusting a focal position at the time of variable power and change of photographic subject distance etc. is possible have been arranged The 1st group of the above is a zoom lens with which it comes to allot the cemented lens of the 1st concave lens, a rectangular prism, the 1st convex lens, the 2nd concave lens, and the 2nd convex lens in order [side / body / above-mentioned].

[Claim 2] The zoom lens according to claim 1 characterized by the 1st group of the above satisfying the conditions of following (1) and (2) mostly.

(1) $1.72 < n_1$ (2) $-7 < \nu_1 - \nu_2 < 15$, however n_1 : -- refractive-index ν_1 : in e line of the medium of the 1st concave lens -- Abbe number ν_2 : in e line of the medium of the 1st concave lens -- the Abbe number in e line of the medium of the 1st convex lens [Claim 3] The zoom lens according to claim 1 characterized by the 1st group of the above satisfying the conditions of following (1) mostly.

(1) $1.65 < n_P$, however n_P : the refractive index in e line of the medium of a rectangular prism

[Claim 4] The zoom lens according to claim 1 characterized by the field by the side of the image of the 2nd convex lens of the 1st group of the above being the aspheric surface.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention is applied to a video camera etc. and relates to a suitable zoom lens. While shortening the length of incident-light shaft orientations sharply by considering in detail the 1st county which constitutes a variable power system as the composition which allotted the cemented lens of the 1st concave lens, a rectangular prism, the 1st convex lens, the 2nd concave lens, and the 2nd convex lens, the field angle of a wide angle edge is applied to the zoom lens which could be made to make front **** small comparatively [latus].

[0002]

[Description of the Prior Art] In recent years, the zoom lens used for a video camera is the so-called inner focus formula zoom lens which moves the 4th group of positive refractive power and adjusts a focal position by positive, negative, positive, and positive refractive-power arrangement as a whole while arranging drawing just before the 3rd group of fixation, moving the 2nd group of negative refractive power and mainly performing variable power. By using this inner focus formula zoom lens, the miniaturization of a video camera can be attained compared with what uses the so-called conventional front ball delivery formula zoom lens (refer to JP,3-33710,A).

[0003]

[Problem(s) to be Solved by the Invention] however, if it thinks also including the thickness of the circuit board placed the thickness of an image pck-up element, and behind an image pck-up element only by having become an inner focus formula zoom lens, and becoming about about 70% by the overall-length ratio together with the effect of an aspheric lens compared with a front ball delivery formula zoom lens although the miniaturization was attained, it will not have contributed to the forge fire by which the optical-system overall length became short at the miniaturization of the whole video camera Although the design of a video camera is mostly decided by the mechanism deck, the cell, and arrangement of a lens, if a lens is arranged not beside an overstatement but beside the mechanism deck of a rectangular parallelepiped, it will turn into a thick design, and if it arranges in front of the mechanism deck, it will turn into a thin and long and slender design.

[0004] This invention aims at offering the zoom lens which can raise the flexibility of a design for a video camera the ** which is not thick long and slender, either. Moreover, this invention aims at solving the fault of the high scale-factor zoom lens for video cameras that the field angle of a wide angle edge is narrow compared with the standard zoom lens for still cameras.

[0005]

[Means for Solving the Problem] The variable power system to which this invention becomes order from the 1st group which has positive refractive power, and the 2nd group which has negative refractive power from a body side, In the zoom lens with which drawing and the 4th group in which movement for having positive refractive power, always having the 3rd group of fixation and positive refractive power, and adjusting a focal position at the time of variable power and change of photographic subject distance etc. is possible have been arranged As for the 1st group, it comes to allot the cemented lens of the 1st concave lens, a rectangular prism, the 1st convex lens, the 2nd concave lens, and the 2nd convex lens in order [side / body].

[0006]

[Function] The beam of light from a body (photographic subject) passes the 1st concave lens which constitutes the 1st group, and the direction of an optical axis is bent right-angled with a rectangular prism, it passes the cemented lens of the 1st convex lens which constitutes the 1st group after that, the 2nd concave lens, and the 2nd convex lens, and incidence is carried out to the 2nd group. An inclination is made small with the 1st concave lens, and incidence of the chief ray is carried out to a rectangular prism. Moreover, an interval spreads by making a rectangular prism intervene, and the lens group of the 1st concave lens, and the 1st convex lens with refractive power positive on the whole, the 2nd concave lens and the 2nd convex lens serves as composition which brings near the posterior principal point of the 1st group back.

[0007]

[Example] Hereafter, one example of the zoom lens concerning this invention is explained, referring to drawing 1. The 1st group 11 which has positive refractive power, the 2nd group 12 which has negative refractive power, drawing 15, the 3rd group 13 which has positive refractive power, and the 4th group 14 which has positive refractive power are arranged, and the zoom lens 10 of this example is constituted from a body side by order. The 1st group 11 and the 2nd group 12 constitute the variable power system, the 2nd group 12 is moved, and variable power is performed. Moreover, a focal position is adjusted by moving the 4th group 14 at the time of variable power and change of photographic subject distance etc. In addition, between the 4th group 14 and the image surface, the light filter 16 which consists of flat-surface glass is arranged.

[0008] The cemented lens of a concave lens L1, rectangular-prism P, a convex lens L2, a concave lens L3, and a convex lens L4 is allotted in order [side / body], and the 1st group 11 is constituted. Rectangular-prism P acts so that the optical axis of the beam of light which passed the concave lens L1 may be bent right-angled. Although a convex lens L4 is made into a spherical lens in the example 1 mentioned later, let the field by the side of an image be the aspheric surface in the example 2 mentioned later. Moreover, a concave lens L5, a concave lens L6, and a convex lens L7 are allotted in order [side / body], and the 2nd group 12 is constituted.

[0009] Moreover, a convex lens L8, a convex lens L9, and a concave lens L10 are arranged in order [side / body], and the 3rd group 13 is constituted. Let the field by the side of the body of a convex lens L8 be the aspheric surface. Moreover, the weak lens L11 and weak biconvex lens L12 of refractive power are arranged in order [side / body], and the 4th group 14 is constituted. A lens L11 is a product made from plastics, and let the field by the side of an image be the aspheric surface. Since a lens L11 has very weak refractive power and thickness is thin, there is the feature that the sensitivity which the contraction at the time of fabrication and the error of the profile irregularity by the temperature change exert on a performance is small, and curtailment and highly-efficient-izing of cost are reconciled.

[0010] Moreover, based on the actual result etc., the zoom lens 10 of this example is formed so that the conditions of the following (1) - (3) may be satisfied. In addition, you may form so that either the conditions of (1) and (2) or the conditions of (3) may be satisfied.

[0011] (1) $1.72 < n_1$ (2) $-7 < n_1 - n_2 < 15$ (3) The Abbe number n_P in e line of the medium of the Abbe-number n_2 :convex lens L2 in e line of the medium of the refractive-index n_1 :concave lens L1 in $1.65 < n_P$, however e line of the medium of the n_1 :concave lens L1: Refractive index in e line of the medium of rectangular-prism P [0012] The conditions of (1) are conditions for the beam-of-light quantity of the chief ray in a wide angle edge suppressing small distortion aberration slack type [generated from the highest concave lens L1], can make r2 page curvature loose by making a refractive index n_i high, and make amendment of distortion aberration easy.

[0013] The conditions of (2) are related with amendment of the chromatic aberration of the scale factor in a wide angle edge. The chromatic aberration of the scale factor generated with the concave lens L1 has the amendment need with the convex lens L2 with the comparatively high beam-of-light quantity of a chief ray. If an upper limit is exceeded, while g line will spread inside if the glass of a concave lens L1 is decided from the conditions of (1), the cost of glass, etc. and

the Abbe number of a convex lens L2 will exceed a minimum for amendment of the chromatic aberration of a scale factor, and g line will spread outside, amendment of the axial overtone aberration of a tele edge becomes difficult.

[0014] It is for making total reflection cause by rectangular-prism P, and it is making high the refractive index n_p of rectangular-prism P, and they enable it to apply total reflection and make [the conditions of (3) enlarge a critical angle,] quantity of light loss the minimum while they make small the inclination within rectangular-prism P of the chief ray of a wide angle edge.

[0015] In the above composition the beam of light from a body (photographic subject) Pass the concave lens L1 which constitutes the 1st group 11, and the direction of an optical axis is bent right-angled by rectangular-prism P. The cemented lens of the convex lens L2 which constitutes the 1st group 11 after that, a concave lens L3, and a convex lens L4 is passed, the 2nd group 12, drawing 15, the 3rd group 13, the 4th group 14, and a light filter 16 are passed further, and the image surface is reached. In this case, although the image on an image pick-up element turns into an image which right and left or the upper and lower sides reversed by bending an optical axis once by rectangular-prism P, in a video camera, it can perform easily changing to an erect normal image by signal processing etc.

[0016] Below, the numerical example of an example 1 and an example 2 is shown. In this numerical example r_i ($i=1-26$) The radius of curvature of the i -th field [mm], A refractive index [in / e line of the j -th medium / d_i ($i=1-25$), and / in n_j ($j=1-13$)], / the i -th spacing [mm] The Abbe number [in / e line of the j -th medium / in n_{uj} ($j=1-13$)], a refractive index / in / e line of the medium of rectangular-prism P / in n_p], and n_{up} are the Abbe numbers in e line of the medium of rectangular-prism P.

[0017] [Example 1]

A. (the radius of curvature of each side, the interval of each side, the refractive index of each medium, Abbe number of each medium)

r_1 400. d_1 1. n_1 1.83930 n_u 1 37.1 r_2 38.253 d_2 4.3 r_3 infinity d_3 10. n_P 1.70559 n_{uP} 40.9 r_4 infinity d_4 9.5 n_P 1.70559 n_{uP} 40.9 r_5 infinity d_5 1. r_6 61.845 d_6 2.75 n_2 1.83930 n_u 2 37.1 r_7 -61.845 d_7 0.2 r_8 16.539 d_8 0.75 n_3 1.85505 n_u 3 23.6 r_9 10.101 d_9 4.815 n_4 1.69980 n_u 4 55.3 r_{10} 62.756 d_{10} 11 94.821 d_{11} 0.5 n_5 1.83930 n_u 5 37.1 r_{12} 5.389 d_{12} 1.72 r_{13} -6.762 d_{13} 0.5 n_6 1.66152 n_u 6 50.6 r_{14} 7.132 d_{14} 1.823 n_7 1.85505 n_u 7 23.6 r_{15} -32.461 d_{15} 16 7.096 d_{16} 4.183 n_8 1.69661 n_u 8 53.0 r_{17} -25.713 d_{17} 20.07 d_{18} 2.064 n_9 1.51872 n_u 9 64.0 r_{19} -29.137 d_{19} 0.5 n_{10} 1.85505 n_u 10 23.6 r_{20} 7.517 d_{20} 10. d_{21} 0.8 n_{11} 1.494 n_u 11 56.8 r_{22} 10. d_{22} 0.2 r_{23} 8.167 d_{23} 2.943 n_{12} 1.51872 n_u 12 64.0 r_{24} -13.305 d_{24} 25 infinity d_{25} 3.32 n_{13} 1.55898 n_u 13 58.3 r_{26} infinity [0018]

B. (aspheric surface coefficient)

An aspheric surface coefficient A4 A6 A8 A10 r_{16} page - 0.3923X10⁻³ -0.4897X10⁻⁵ 0.3836X10⁻⁷ The -0.3000X10⁻⁸ r_{22} Page 0.9229x10⁻³ 0.1212x10⁻⁴ -0.4148x10⁻⁸ The definition of the 0.1810x10⁻⁸ aspheric surface: $1+(1-H^2/r_i^2) 1/\chi_{ii}=H^2/r_i^2+\sigma A_j H_j$, however depth [of the χ_{ii} :aspheric surface] H : Height from an optical axis [0019] C. (the position of drawing, focal position)

Drawing is 0.7mm of r_{16} page front, and a focal position is 2.0mm [0020] of r_{26} page back. D. (interval of each field corresponding to focal distance f [mm])

Focal distance f 3.72 14.296 28.644 f numbers 1.43 1.92 2.35 d_{10} 0.9 10.172 13.507 d_{15} 14.757 5.485 2.15 d_{20} 3.884 1.441 3.874 d_{24} 2.213 4.657 2.223 [0021] Drawing 2 , drawing 3 , and drawing 4 show the spherical aberration at the time of being $f= 3.72$, $f= 14.296$, and $f= 28.644$, respectively, astigmatism, and distortion aberration. That is, drawing 2 can set the focal distance of middle [drawing 3 / a wide angle edge and], and drawing 4 to a tele edge. In drawing 2 - drawing 4 , spherical aberration [in / e line / in a solid line e], spherical aberration / in / c line / in an alternate long and short dash line c], and the dashed line g show the spherical aberration in g line. Moreover, in drawing 2 - drawing 4 , astigmatism [in / a sagittal plane / in a solid line S] and a dashed line M are the astigmatism in a meridional plane. In addition, F shows the f number and omega shows the half-field angle.

[0022] [Example 2]

A. (the radius of curvature of each side, the interval of each side, the refractive index of each

medium, Abbe number of each medium)

r1 315.511 d1 1. n1 1.77621 nu 1 49.4r2 35.068 d2 6.464r3 infinity d3 10. nP 1.70559 nuP 40.9r4 infinity d4 9.5 nP 1.70559 nuP 40.9r5 infinity d5 0.5r6 25.67 d6 3.62 n2 1.83930 nu 2 37.1r7 - 270.691 d7 0.2r8 24.568 d8 0.75 n3 1.85505 nu 3 23.6r9 11.111 d9 4.702 n4 1.69661 nu 4 53.0r10 75.94 d10r11 20.69 d11 0.5 n5 1.83962 nu 5 42.8r12 5.469 d12 2.064r13 -6.748 d13 0.5 n61.66152 nu 6 50.6r147.407 d14 1.765 n7 1.85505 nu 7 23.6r15 -80.117 d15r16 8.771 d16 2.897 n8 1.69661 nu 8 53.0r17 -79.477 d17 0.2r18 7.106 d18 3.111 n9 1.51978 nu 9 51.9r19 -66.263 d19 0.5n10 1.85505 nu 10 23.6r20 5.762 d20r21 10. d21 0.8 n11 1.494 nu 11 56.8r22 10. d22 0.2r23 7.657 d23 2.691 n12 1.51872 nu 12 64.0r24 -16.529 d24r25 infinity d25 3.32 n13 1.55898 nu 13 58.3r26 infinity [0023]

B. (aspheric surface coefficient)

Aspheric surface coefficient A4 A6 A8 A10r10 page 0.1383x10⁻⁴ The 0.4175x10⁻⁷r16th page - 0.1518x10⁻³ The -0.1521x10⁻⁵r22nd page 0.9186x10⁻³ -0.1178x10⁻⁴ 0.1273x10⁻⁵ -0.2186x10⁻⁷ [0024] C. (the position of drawing, focal position)

Drawing is 0.7mm of r16 page front, and a focal position is 2.0mm [0025] of r26 page back. D. (interval of each field corresponding to focal distance f [mm])

Focal distance f 3.72 17.336 35.711 f numbers 1.63 1.88 2.55d10 0.9 12.482 16.214d15 17.464 5.882 2.15d20 4.826 1.555 4.816d24 2.104 5.285 2.024 [0026] Drawing 5, drawing 6, and drawing 7 show the spherical aberration at the time of being f= 3.72, f= 17.336, and f= 35.711, respectively, astigmatism, and distortion aberration. That is, drawing 5 can set the focal distance of middle [drawing 6 / a wide angle edge and], and drawing 7 to a tele edge. In drawing 5 - drawing 7, spherical aberration [in / e line / in a solid line e], spherical aberration / in / c line / in an alternate long and short dash line c], and the dashed line g show the spherical aberration in g line. Moreover, in drawing 5 - drawing 7, astigmatism [in / a sagittal plane / in a solid line S] and a dashed line M are the astigmatism in a meridional plane. In addition, F shows the f number and omega shows the half-field angle.

[0027] In the zoom lens 10 of this example explained above, since an optical axis is bent right-angled by rectangular-prism P which constitutes the 1st group 11, the length of incident-light shaft orientations can be shortened sharply. Therefore, when using it, for example for a video camera, it cannot long and slender be [thick or] about a video camera by arranging in front of the mechanism deck of a rectangular parallelepiped.

[0028] Moreover, comparatively [latus] in the zoom lens 10 of this example, the field angle of a wide angle edge can make front **** small. That is, since rectangular-prism P is arranged after making the inclination of a chief ray small with a concave lens L1, although a field angle is large, rectangular-prism P is small and ends. Moreover, an interval spreads because rectangular-prism P intervenes, and since a concave lens L1 and the lens group of L2, L3, and L4 with refractive power positive on the whole serve as composition which brings near the posterior principal point of the 1st group 11 back, they can shorten the focal distance of the 1st group 11, and become advantageous to wide-angle-izing.

[0029] In addition, rectangular-prism P of the size which considering the case where rectangular-prism P is arranged in front of the conventional zoom lens includes a field angle is needed, and if it wide-angle-izes, rectangular-prism P will become huge. Moreover, considering the case where extend the interval of the 1st group 11 and the 2nd group 12, and rectangular-prism P is arranged, between the 1st group 11 and the 2nd group 12, since the inclination of a chief ray is larger than an incidence inclination, rectangular-prism P becomes still huger. It stops furthermore, considering the case where rectangular-prism P is arranged more back than the move space of the 2nd group 12, being able to shorten the length of an incident-light shaft sharply.

[0030] Moreover, in the zoom lens 10 of this example, since the field by the side of the image of the convex lens 14 which constitutes the 1st group 11 was made into the aspheric surface, shortening the lens overall length after bending an optical axis, and high scale-factor-ization of a zoom ratio can be reconciled. That is, if refractive power of the 1st group 11 and the 2nd group 12 tends to be strengthened and it is going to obtain a big variable power ratio with the small movement magnitude of the 2nd group 12, amendment of the spherical aberration and comatic

aberration which are generated from the 1st group 11 in a tele edge will become difficult. The aspheric surface can be used for the 1st group 11, and a big effect can be acquired by aspheric-surface-izing spherical aberration of an amendment deficit type in the amendment direction to the paraxial spherical surface. Although the same effect will be acquired if the aspheric surface is introduced into either of the lenses L2, L3, and L4 with which the flux of light spread, by considering as the aspheric surface, manufacture of the aspheric surface can be easy and a lens L4 can be realized cheaply.

[0031]

[Effect of the Invention] Since this invention considers the 1st group which constitutes a variable power system as the composition which allotted the cemented lens of the 1st concave lens, a rectangular prism, the 1st convex lens, the 2nd concave lens, and the 2nd convex lens, it can shorten the length of incident-light shaft orientations sharply. By arranging in front of the mechanism deck of a rectangular parallelepiped by this, when using it for a video camera, it cannot long and slender be [thick or] about a video camera, and the flexibility of a design can be raised.

[0032] Moreover, since the rectangular prism is arranged after the rectangular prism is arranged between the 1st concave lens and the 1st convex lens and makes the inclination of a chief ray small with the 1st concave lens, although a field angle is large, a rectangular prism is small and ends. And an interval spreads because a rectangular prism intervenes, and since the lens group of the 1st concave lens, and the 1st convex lens with refractive power positive on the whole, the 2nd concave lens and the 2nd convex lens serves as composition which brings near the posterior principal point of the 1st group back, it can shorten the focal distance of the 1st group and becomes advantageous to wide-angle-izing. Thereby, comparatively [latus], the field angle of a wide angle edge can make front **** small.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the composition of the example of the zoom lens concerning this invention.

[Drawing 2] It is drawing showing the spherical aberration in the wide angle edge of an example 1, astigmatism, and distortion aberration.

[Drawing 3] It is drawing showing the spherical aberration in the middle focal distance of an example 1, astigmatism, and distortion aberration.

[Drawing 4] It is drawing showing the spherical aberration in the tele edge of an example 1, astigmatism, and distortion aberration.

[Drawing 5] It is drawing showing the spherical aberration in the wide angle edge of an example 2, astigmatism, and distortion aberration.

[Drawing 6] It is drawing showing the spherical aberration in the middle focal distance of an example 2, astigmatism, and distortion aberration.

[Drawing 7] It is drawing showing the spherical aberration in the tele edge of an example 2, astigmatism, and distortion aberration.

[Description of Notations]

10 Zoom Lens

11 1st Group

12 2nd Group

13 3rd Group

14 4th Group

15 Drawing

16 Light Filter

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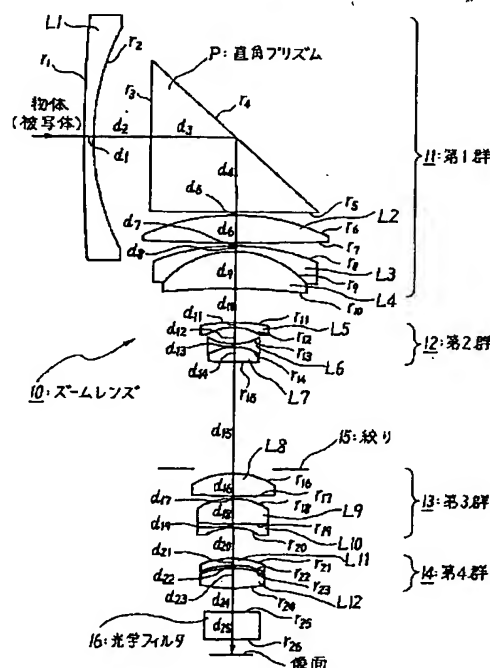
(54) 【発明の名称】 ズームレンズ

(57) 【要約】

【目的】 ビデオカメラを分厚くも細長くもせずにデザインの自由度を高めることができ、また広角端の画角が広い割には前玉径を小さくできるズームレンズを得る。

【構成】 物体側より順に、正の屈折力を有する第1群11と、負の屈折力を有する第2群12と、絞り15と、正の屈折力を有する第3群13と、正の屈折力を有する第4群14とを配置してズームレンズ10を構成する。第1群11と第2群12は変倍系を構成する。凹レンズL1、直角プリズムP、凸レンズL2、凹レンズL3及び凸レンズL4の接合レンズを物体側より順に配して第1群11を構成する。物体からの光線の光軸は直角プリズムPで直角に曲げられるため、入射光軸方向の長さが大幅に短くなる。直角プリズムPの介在で凹レンズL1とL2～L4のレンズ群の間隔が広がって第1群11の後側主点を後ろに寄せる構成となり、第1群11の焦点距離を短くできて広角化に有利となる。

実施例の構成



【特許請求の範囲】

【請求項1】 物体側より順に、正の屈折力を有する第1群と負の屈折力を有する第2群とよりなる変倍系と、絞りと、正の屈折力を有し常時固定の第3群と、正の屈折力を有し変倍時および被写体距離の変化時等に焦点位置を調節するための移動可能な第4群とが配置されたズームレンズにおいて、

上記第1群は、第1の凹レンズ、直角プリズム、第1の凸レンズ、第2の凹レンズおよび第2の凸レンズの接合レンズが上記物体側より順に配されてなるズームレンズ。

【請求項2】 上記第1群が下記(1)、(2)の条件をほぼ満足することを特徴とする請求項1に記載のズームレンズ。

$$(1) \quad 1.72 < n_1$$

$$(2) \quad -7 < \nu_1 - \nu_2 < 15$$

ただし、 n_1 ：第1の凹レンズの媒質のe線における屈折率

ν_1 ：第1の凹レンズの媒質のe線におけるアッペ数

ν_2 ：第1の凸レンズの媒質のe線におけるアッペ数

【請求項3】 上記第1群が下記(1)の条件をほぼ満足することを特徴とする請求項1に記載のズームレンズ。

$$(1) \quad 1.65 < n_p$$

ただし、 n_p ：直角プリズムの媒質のe線における屈折率

【請求項4】 上記第1群の第2の凸レンズの像側の面が非球面であることを特徴とする請求項1に記載のズームレンズ。

【発明の詳細な説明】

【0001】

【産業上の利用分野】 この発明は、例えばビデオカメラ等に適用して好適なズームレンズに関する。詳しくは、変倍系を構成する第1群を第1の凹レンズ、直角プリズム、第1の凸レンズ、第2の凹レンズおよび第2の凸レンズの接合レンズを配した構成とすることによって、入射光軸方向の長さを大幅に短くすると共に、広角端の画角が広い割に前玉径を小さくできるようにしたズームレンズに係るものである。

【0002】

【従来の技術】 近年、ビデオカメラに使用されるズームレンズは、全体として正、負、正、正の屈折力配置で、固定の第3群の直前に絞りを配置し、負の屈折力の第2群を移動して主に変倍を行うと共に、正の屈折力の第4群を移動して焦点位置を調節する、いわゆるインナーフォーカス式ズームレンズになっている。このインナーフォーカス式ズームレンズを使用することで、従来のいわゆる前玉繰り出し式ズームレンズを使用するものに比べてビデオカメラの小型化を達成できる（特開平3-33710号公報参照）。

【0003】

【発明が解決しようとする課題】 しかし、インナーフォーカス式ズームレンズになって小型化が達成されたと言っても、非球面レンズの効果と合わせて、前玉繰り出し式ズームレンズに比べて全長比でおよそ70%程度になっただけで、撮像素子の厚みや撮像素子の後ろに置く回路基板の厚みも含めて考えると、光学系全長が短くなったほどには、ビデオカメラ全体の小型化には寄与していない。ビデオカメラのデザインは、メカデッキと電池とレンズの配置とでほぼ決まると言っても過言ではなく、直方体のメカデッキの横にレンズを配置すれば分厚いデザインになり、メカデッキの前に配置すれば薄くて細長いデザインとなる。

【0004】 この発明は、ビデオカメラを分厚くも細長くもせずにデザインの自由度を高めることができるズームレンズを提供することを目的とする。また、この発明は、スチルカメラ用標準ズームレンズに比べて広角端の画角が狭いというビデオカメラ用高倍率ズームレンズの欠点を解決することを目的とする。

【0005】

【課題を解決するための手段】 この発明は、物体側より順に、正の屈折力を有する第1群と負の屈折力を有する第2群とよりなる変倍系と、絞りと、正の屈折力を有し常時固定の第3群と、正の屈折力を有し変倍時および被写体距離の変化時等に焦点位置を調節するための移動可能な第4群とが配置されたズームレンズにおいて、第1群は、第1の凹レンズ、直角プリズム、第1の凸レンズ、第2の凹レンズおよび第2の凸レンズの接合レンズが物体側より順に配されてなるものである。

【0006】

【作用】 物体（被写体）からの光線は、第1群を構成する第1の凹レンズを通過し、直角プリズムで光軸方向が直角に曲げられ、その後に第1群を構成する第1の凸レンズ、第2の凹レンズおよび第2の凸レンズの接合レンズを通過して第2群に入射される。主光線は第1の凹レンズで傾角が小さくされて直角プリズムに入射される。また、第1の凹レンズと全体で正の屈折力を持つ第1の凸レンズ、第2の凹レンズ、第2の凸レンズのレンズ群とは直角プリズムを介在させることで間隔が広がり、第1群の後側主点を後ろに寄せる構成となる。

【0007】

【実施例】 以下、図1を参照しながら、この発明に係るズームレンズの一実施例について説明する。本例のズームレンズ10は、物体側より順に、正の屈折力を有する第1群11と、負の屈折力を有する第2群12と、絞り15と、正の屈折力を有する第3群13と、正の屈折力を有する第4群14とが配置されて構成される。第1群11と第2群12とは変倍系を構成しており、第2群12を移動して変倍が行われる。また、第4群14を移動させることで変倍時および被写体距離の変化時等に焦点

位置が調節される。なお、第4群14と像面との間には平面ガラスよりなる光学フィルタ16が配置される。

【0008】第1群11は、凹レンズL1、直角プリズムP、凸レンズL2、凹レンズL3および凸レンズL4の接合レンズが物体側より順に配されて構成される。直角プリズムPは、凹レンズL1を通過した光線の光軸を直角に曲げるように作用する。凸レンズL4は、後述する実施例1では球面レンズとされるが、後述する実施例2では像側の面が非球面とされる。また、第2群12は、凹レンズL5、凹レンズL6および凸レンズL7が物体側より順に配されて構成される。

【0009】また、第3群13は、凸レンズL8、凸レンズL9および凹レンズL10が物体側より順に配されて構成される。凸レンズL8の物体側の面は非球面とされる。また、第4群14は、屈折力の弱いレンズL11および両凸レンズL12が物体側より順に配されて構成される。レンズL11はプラスチック製で、像側の面は非球面とされる。レンズL11は屈折力が極めて弱く、厚みが薄いので、成形時の収縮や温度変化による面精度の誤差が性能に及ぼす敏感度が小さいという特長があり、コストの削減と高性能化を両立させている。

【0010】また、本例のズームレンズ10は、実結果等に基づき、以下の(1)～(3)の条件を満足するように形成されている。なお、(1)および(2)の条件、または(3)の条件のいずれかを満足するように形成してもよい。

$$【0011】(1) \quad 1.72 < n_1$$

$$(2) \quad -7 < \nu_1 - \nu_2 < 15$$

$$(3) \quad 1.65 < n_p$$

ただし、 n_1 : 凹レンズL1の媒質のe線における屈折率

ν_1 : 凹レンズL1の媒質のe線におけるアッペ数

ν_2 : 凸レンズL2の媒質のe線におけるアッペ数

n_p : 直角プリズムPの媒質のe線における屈折率

【0012】(1)の条件は、広角端における主光線の光線高が最も高い凹レンズL1から発生する樽型の歪曲収差を小さく抑えるための条件で、屈折率 n_1 を高くす

ることで r_2 面の曲率を緩くでき、歪曲収差の補正を容易にする。

【0013】(2)の条件は、広角端における倍率の色収差の補正に関するものである。凹レンズL1で発生した倍率の色収差は、主光線の光線高が比較的高い凸レンズL2で補正する必要がある。(1)の条件とガラスのコストなどから凹レンズL1のガラスを決めると、倍率の色収差の補正には凸レンズL2のアッペ数が下限を越えるとg線が内側に滲み、上限を越えるとg線が外側に滲むとともに望遠端の軸上色収差の補正が困難となる。

【0014】(3)の条件は、直角プリズムPで全反射を起こさせるためのもので、直角プリズムPの屈折率 n_p を高くすることで、広角端の主光線の直角プリズムP内での傾角を小さくするとともに、臨界角を大きくして全反射を応用できるようにし、光量損失を最小限にする。

【0015】以上の構成において、物体(被写体)からの光線は、第1群11を構成する凹レンズL1を通過し、直角プリズムPで光軸方向が直角に曲げられ、その後第1群11を構成する凸レンズL2、凹レンズL3および凸レンズL4の接合レンズを通過し、さらに第2群12、絞り15、第3群13、第4群14および光学フィルタ16を通過して像面に到達する。この場合、直角プリズムPで光軸を1回折り曲げることにより、撮像素子上の像は左右または上下が反転した像となるが、ビデオカメラでは信号処理などで正立正像に直すことは容易にできる。

【0016】以下に、実施例1および実施例2の数値例を示す。この数値例において、 r_i ($i=1\sim 26$)はi番目の面の曲率半径[mm]、 d_i ($i=1\sim 25$)はi番目の面間隔[mm]、 n_j ($j=1\sim 13$)はj番目の媒質のe線における屈折率、 ν_j ($j=1\sim 13$)はj番目の媒質のe線におけるアッペ数、 n_p は直角プリズムPの媒質のe線における屈折率、 ν_p は直角プリズムPの媒質のe線におけるアッペ数である。

【0017】[実施例1]

A. (各面の曲率半径、各面の間隔、各媒質の屈折率、各媒質のアッペ数)

| | | | | | | | |
|----------|----------|----------|-------|-------|---------|---------|------|
| r_1 | 400. | d_1 | 1. | n_1 | 1.83930 | ν_1 | 37.1 |
| r_2 | 38.253 | d_2 | 4.3 | | | | |
| r_3 | ∞ | d_3 | 10. | n_p | 1.70559 | ν_p | 40.9 |
| r_4 | ∞ | d_4 | 9.5 | n_p | 1.70559 | ν_p | 40.9 |
| r_5 | ∞ | d_5 | 1. | | | | |
| r_6 | 61.845 | d_6 | 2.75 | n_2 | 1.83930 | ν_2 | 37.1 |
| r_7 | -61.845 | d_7 | 0.2 | | | | |
| r_8 | 16.539 | d_8 | 0.75 | n_3 | 1.85505 | ν_3 | 23.6 |
| r_9 | 10.101 | d_9 | 4.815 | n_4 | 1.69980 | ν_4 | 55.3 |
| r_{10} | 62.756 | d_{10} | | | | | |
| r_{11} | 94.821 | d_{11} | 0.5 | n_5 | 1.83930 | ν_5 | 37.1 |
| r_{12} | 5.389 | d_{12} | 1.72 | | | | |

| | | | | | | | |
|-----------------|---------|-----------------|-------|-----------------|---------|-----------------|------|
| r ₁₃ | -6.762 | d ₁₃ | 0.5 | n ₆ | 1.66152 | v ₆ | 50.6 |
| r ₁₄ | 7.132 | d ₁₄ | 1.823 | n ₇ | 1.85505 | v ₇ | 23.6 |
| r ₁₅ | -32.461 | d ₁₅ | | | | | |
| r ₁₆ | 7.096 | d ₁₆ | 4.183 | n ₈ | 1.69661 | v ₈ | 53.0 |
| r ₁₇ | -25.713 | d ₁₇ | 0.2 | | | | |
| r ₁₈ | 20.07 | d ₁₈ | 2.064 | n ₉ | 1.51872 | v ₉ | 64.0 |
| r ₁₉ | -29.137 | d ₁₉ | 0.5 | n ₁₀ | 1.85505 | v ₁₀ | 23.6 |
| r ₂₀ | 7.517 | d ₂₀ | | | | | |
| r ₂₁ | 10. | d ₂₁ | 0.8 | n ₁₁ | 1.494 | v ₁₁ | 56.8 |
| r ₂₂ | 10. | d ₂₂ | 0.2 | | | | |
| r ₂₃ | 8.167 | d ₂₃ | 2.943 | n ₁₂ | 1.51872 | v ₁₂ | 64.0 |
| r ₂₄ | -13.305 | d ₂₄ | | | | | |
| r ₂₅ | ∞ | d ₂₅ | 3.32 | n ₁₃ | 1.55898 | v ₁₃ | 58.3 |
| r ₂₆ | ∞ | | | | | | |

【0018】

B. (非球面係数)

| 非球面係数 | A ₄ | A ₆ | A ₈ | A ₁₀ |
|-------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| r ₁₆ 面 | -0.3923×10 ⁻³ | -0.4897×10 ⁻⁵ | 0.3836×10 ⁻⁷ | -0.3000×10 ⁻⁸ |
| r ₂₂ 面 | 0.9229×10 ⁻³ | 0.1212×10 ⁻⁴ | -0.4148×10 ⁻⁸ | 0.1810×10 ⁻⁸ |

非球面の定義： $\chi_i = H^2 / r_i \{ 1 + (1 - H^2 / r_i^2)^{1/2} \} + \sum A_j H^j$

ただし、 χ_i ：非球面の深さ

H：光軸からの高さ

【0019】C. (絞りの位置、焦点位置)

絞りはr₁₆面の前方0.7mm、焦点位置はr₂₆面の後方2.0mm

【0020】D. (焦点距離f[mm]に対応した各面の間隔)

| | | | |
|-----------------|--------|--------|--------|
| 焦点距離 f | 3.72 | 14.296 | 28.644 |
| Fナンバー | 1.43 | 1.92 | 2.35 |
| d ₁₀ | 0.9 | 10.172 | 13.507 |
| d ₁₅ | 14.757 | 5.485 | 2.15 |

A. (各面の曲率半径、各面の間隔、各媒質の屈折率、各媒質のアッペ数)

| | | | | | | | |
|-----------------|----------|-----------------|-------|----------------|---------|----------------|------|
| r ₁ | 315.511 | d ₁ | 1. | n ₁ | 1.77621 | v ₁ | 49.4 |
| r ₂ | 35.068 | d ₂ | 6.464 | | | | |
| r ₃ | ∞ | d ₃ | 10. | n _p | 1.70559 | v _p | 40.9 |
| r ₄ | ∞ | d ₄ | 9.5 | n _p | 1.70559 | v _p | 40.9 |
| r ₅ | ∞ | d ₅ | 0.5 | | | | |
| r ₆ | 25.67 | d ₆ | 3.62 | n ₂ | 1.83930 | v ₂ | 37.1 |
| r ₇ | -270.691 | d ₇ | 0.2 | | | | |
| r ₈ | 24.568 | d ₈ | 0.75 | n ₃ | 1.85505 | v ₃ | 23.6 |
| r ₉ | 11.111 | d ₉ | 4.702 | n ₄ | 1.69661 | v ₄ | 53.0 |
| r ₁₀ | 75.94 | d ₁₀ | | | | | |
| r ₁₁ | 20.69 | d ₁₁ | 0.5 | n ₅ | 1.83962 | v ₅ | 42.8 |
| r ₁₂ | 5.469 | d ₁₂ | 2.064 | | | | |
| r ₁₃ | -6.748 | d ₁₃ | 0.5 | n ₆ | 1.66152 | v ₆ | 50.6 |
| r ₁₄ | 7.407 | d ₁₄ | 1.765 | n ₇ | 1.85505 | v ₇ | 23.6 |
| r ₁₅ | -80.117 | d ₁₅ | | | | | |
| r ₁₆ | 8.771 | d ₁₆ | 2.897 | n ₈ | 1.69661 | v ₈ | 53.0 |
| r ₁₇ | -79.477 | d ₁₇ | 0.2 | | | | |

【0021】図2、図3および図4は、それぞれf=3.72、f=14.296およびf=28.644であるときの球面収差、非点収差、歪曲収差を示している。すなわち、図2は広角端、図3は中間の焦点距離、図4は望遠端におけるものである。図2～図4において、実線eはe線における球面収差、一点鎖線cはc線における球面収差、破線gはg線における球面収差を示している。また、図2～図4において、実線Sはサジタル平面における非点収差、破線Mはメリジオナル平面における非点収差である。なお、FはFナンバー、ωは半画角を示している。

【0022】[実施例2]

| | | | | | | | |
|----------|----------|----------|-------|----------|---------|------------|------|
| r_{18} | 7.106 | d_{18} | 3.111 | n_9 | 1.51978 | ν_9 | 51.9 |
| r_{19} | -66.263 | d_{19} | 0.5 | n_{10} | 1.85505 | ν_{10} | 23.6 |
| r_{20} | 5.762 | d_{20} | | | | | |
| r_{21} | 10. | d_{21} | 0.8 | n_{11} | 1.494 | ν_{11} | 56.8 |
| r_{22} | 10. | d_{22} | 0.2 | | | | |
| r_{23} | 7.657 | d_{23} | 2.691 | n_{12} | 1.51872 | ν_{12} | 64.0 |
| r_{24} | -16.529 | d_{24} | | | | | |
| r_{25} | ∞ | d_{25} | 3.32 | n_{13} | 1.55898 | ν_{13} | 58.3 |
| r_{26} | ∞ | | | | | | |

【0023】

B. (非球面係数)

| 非球面係数 | A_4 | A_6 | A_8 | A_{10} |
|------------|--------------------------|--------------------------|-------------------------|--------------------------|
| r_{10} 面 | 0.1383×10^{-4} | 0.4175×10^{-7} | | |
| r_{16} 面 | -0.1518×10^{-3} | -0.1521×10^{-5} | | |
| r_{22} 面 | 0.9186×10^{-3} | -0.1178×10^{-4} | 0.1273×10^{-5} | -0.2186×10^{-7} |

【0024】C. (絞りの位置、焦点位置)

絞りは r_{16} 面の前方 0.7mm、焦点位置は r_{26} 面の後方 2.0mm

【0025】D. (焦点距離 f [mm] に対応した各面の間隔)

| | | | |
|----------|--------|--------|--------|
| 焦点距離 f | 3.72 | 17.336 | 35.711 |
| F ナンバー | 1.63 | 1.88 | 2.55 |
| d_{10} | 0.9 | 12.482 | 16.214 |
| d_{15} | 17.464 | 5.882 | 2.15 |
| d_{20} | 4.826 | 1.555 | 4.816 |
| d_{24} | 2.104 | 5.285 | 2.024 |

【0026】図5、図6および図7は、それぞれ $f=3.72$ 、 $f=17.336$ および $f=35.711$ であるときの球面収差、非点収差、歪曲収差を示している。すなわち、図5は広角端、図6は中間の焦点距離、図7は望遠端におけるものである。図5～図7において、実線 e は e 線における球面収差、一点鎖線 c は c 線における球面収差、破線 g は g 線における球面収差を示している。また、図5～図7において、実線 S はサジタル平面における非点収差、破線 M はメリジオナル平面における非点収差である。なお、 F は F ナンバー、 ω は半画角を示している。

【0027】以上説明した本例のズームレンズ10においては、第1群11を構成する直角プリズムPで光軸が直角に曲げられるため、入射光軸方向の長さを大幅に短くできる。そのため、例えばビデオカメラに使用する場合、直方体のメカデッキの前に配置することで、ビデオカメラを分厚くも細長くもしないようにできる。

【0028】また、本例のズームレンズ10においては、広角端の画角が広いわりには前玉径を小さくできる。すなわち、凹レンズL1で主光線の傾角を小さくしたあとに直角プリズムPを配置しているので、画角が広いにも拘らず直角プリズムPは小さくて済む。また、凹レンズL1と全体で正の屈折力を持つL2、L3、L4のレンズ群とは、直角プリズムPが介在されることで間隔が広がり、第1群11の後側主点を後ろに寄せる構成

となるため、第1群11の焦点距離を短くできて広角化に有利となる。

【0029】なお、直角プリズムPを従来のズームレンズの前に配置する場合を考えると、画角を包含する大きさの直角プリズムPが必要となり、広角化すると直角プリズムPが巨大になる。また、第1群11と第2群12の間隔を広げて直角プリズムPを配置する場合を考えると、第1群11と第2群12の間では主光線の傾角が入射傾角より大きいいため、直角プリズムPはさらに巨大になる。さらに、第2群12の移動空間より後ろに直角プリズムPを配置する場合を考えると、入射光軸の長さを大幅に短くできなくなる。

【0030】また、本例のズームレンズ10においては、第1群11を構成する凸レンズ14の像側の面を非球面としたので、光軸を折り曲げた後のレンズ全長を短縮することと、ズーム比の高倍率化とを両立させることができる。すなわち、第1群11と第2群12の屈折力を強くして第2群12の小さい移動量で大きな変倍比を得ようとする、望遠端で第1群11から発生する球面収差とコマ収差の補正が困難になる。第1群11に非球面を使い、近軸球面に対して補正不足型の球面収差を補正する方向に非球面化することで大きな効果を得ることができる。光束が広がったレンズL2、L3、L4のいずれかに非球面を導入すれば同様の効果が得られるが、レンズL4を非球面とすることで、非球面の製造が容易で安価に実現できる。

【0031】

【発明の効果】この発明は、変倍系を構成する第1群を第1の凹レンズ、直角プリズム、第1の凸レンズ、第2の凹レンズおよび第2の凸レンズの接合レンズを配した構成とするため、入射光軸方向の長さを大幅に短くできる。これにより、例えばビデオカメラに使用する場合に直方体のメカデッキの前に配置することで、ビデオカメラを分厚くも細長くもしないようにでき、デザインの自由度を高めることができる。

【0032】また、直角プリズムが第1の凹レンズと第1の凸レンズとの間に配されており、第1の凹レンズで主光線の傾角を小さくしたあとに直角プリズムを配置しているため、画角が広いにも拘らず直角プリズムは小さくて済む。しかも、第1の凹レンズと全体で正の屈折力を持つ第1の凸レンズ、第2の凹レンズ、第2の凸レンズのレンズ群とは、直角プリズムが介在されることで間隔が広がり、第1群の後側主点を後ろに寄せる構成となるため、第1群の焦点距離を短くできて広角化に有利となる。これにより、広角端の画角が広いわりには前玉径を小さくできる。

【図面の簡単な説明】

【図1】この発明に係るズームレンズの実施例の構成を示す図である。

【図2】実施例1の広角端における球面収差、非点収差、歪曲収差を示す図である。

【図3】実施例1の中間の焦点距離における球面収差、

非点収差、歪曲収差を示す図である。

【図4】実施例1の望遠端における球面収差、非点収差、歪曲収差を示す図である。

【図5】実施例2の広角端における球面収差、非点収差、歪曲収差を示す図である。

【図6】実施例2の中間の焦点距離における球面収差、非点収差、歪曲収差を示す図である。

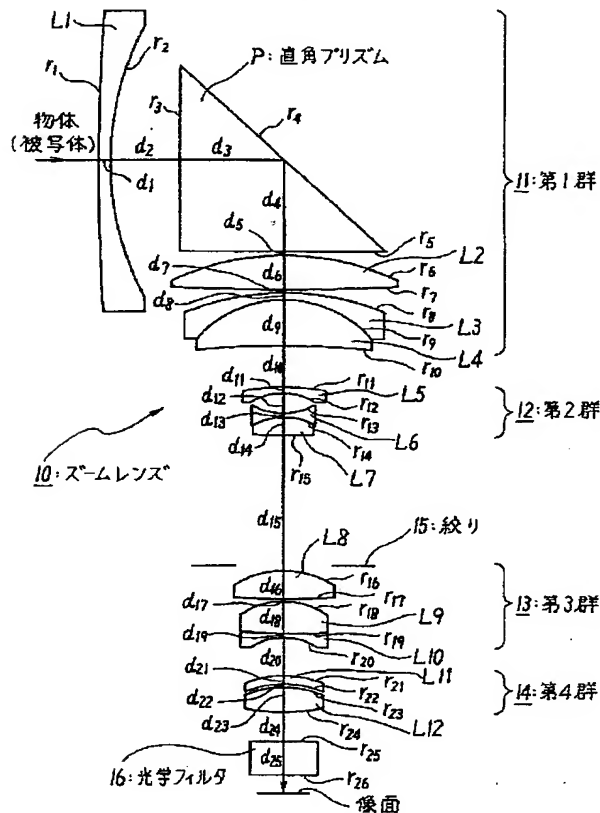
【図7】実施例2の望遠端における球面収差、非点収差、歪曲収差を示す図である。

【符号の説明】

- 10 ズームレンズ
- 11 第1群
- 12 第2群
- 13 第3群
- 14 第4群
- 15 絞り
- 16 光学フィルタ

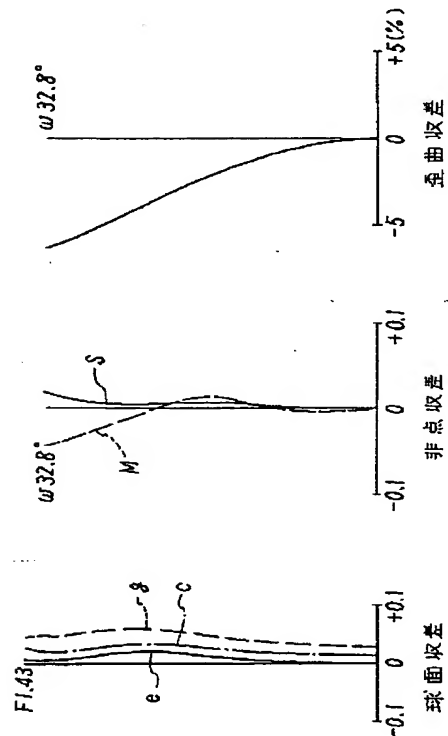
【図1】

実施例の構成



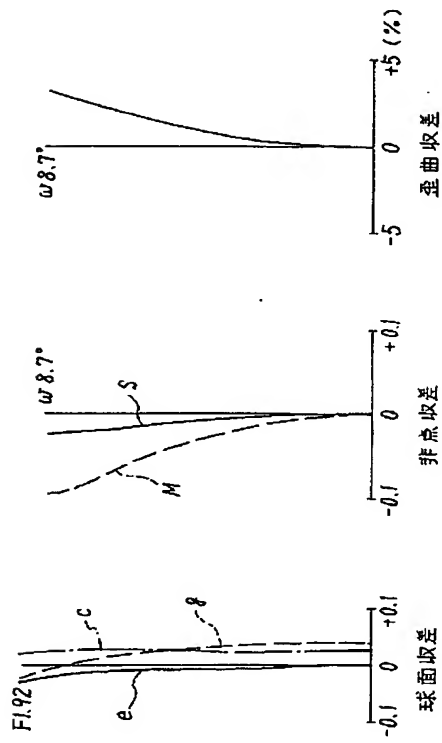
【図2】

実施例1の広角端における球面収差、非点収差、歪曲収差



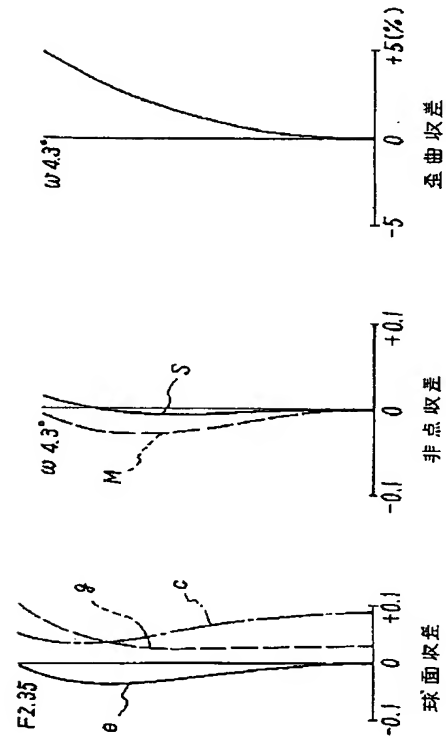
【図3】

実施例1の中間の焦点距離における
球面収差, 非点収差, 歪曲収差



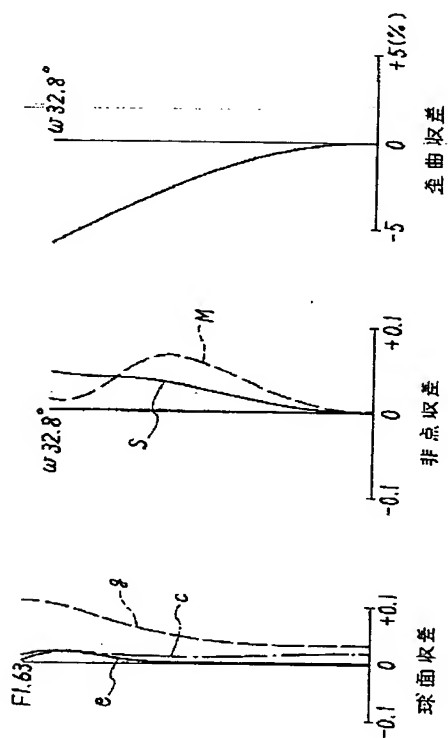
【図4】

実施例1の望遠端における球面収差, 非点収差, 歪曲収差



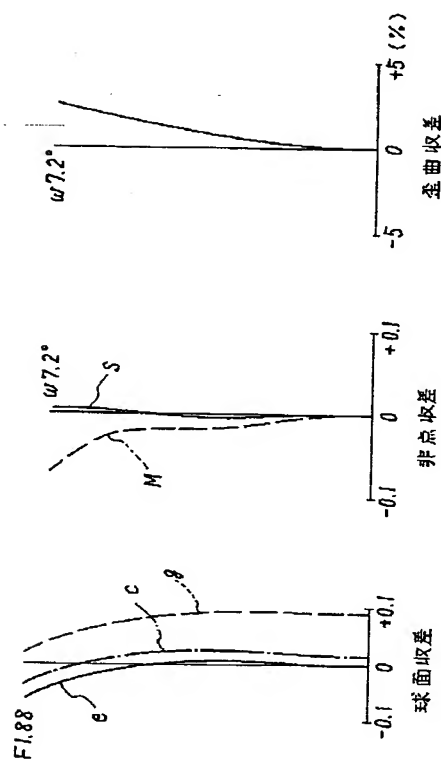
【図5】

実施例2の広角端における球面収差, 非点収差, 歪曲収差



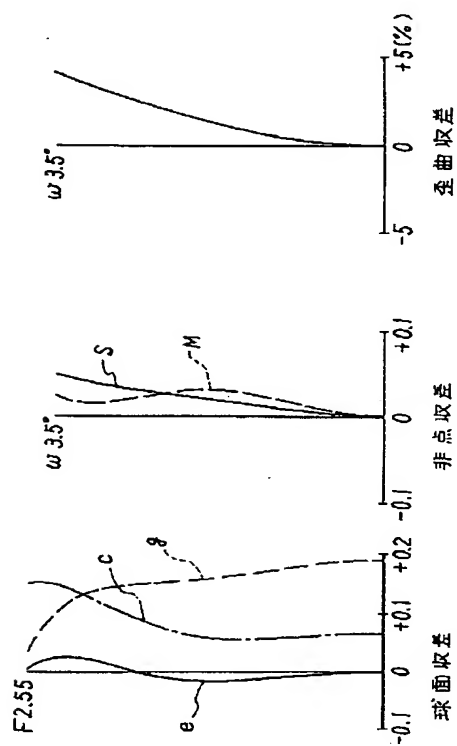
【図6】

実施例2の中間の焦点距離における球面収差, 非点収差, 歪曲収差



【図7】

実施例2の望遠端における球面収差、非点収差、歪曲収差



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